Contents

• Penman Monteith
• Atmospheric turbulence
• Vegetation canopy
• Heterogeneity
• Future structure
Surface Energy Balance
SEB Equations

\[ \alpha = \frac{dq_{sat}}{dT} \bigg|_{T_r} \]
\[ \alpha (T_s - T_r) + q_{sat}(T_r) \]

\[ q_{sat}(T) \]

\[ q_{sat}(T_r) \]

\[ \lambda E = \frac{\rho \lambda}{r_a + r_s} (q_{sat}(T_s) - q_a) \]

\[ G = A_s (T_s - T_{s1}) \]

\[ R_n = H + \lambda E + G \]
Monin-Obukhov similarity theory

\[
\frac{dU}{dz} = \frac{1}{\kappa z} u_*,
\]

\[
u_* = f_1(z/L) \quad H = f_2(z/L) \quad L = f_3(u_*, H)
\]
Impact of stable stability functions

Log linear

Heat Flux (W m$^{-2}$)

Beljaars and Holtslag

Temperature Difference (K)

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Canopy Surface Energy Balance
SEB Equations for Canopy

\[ G = A_s (T_s - T_{s1}) \]
\[ R_n = H + \lambda E + G \]

\[ S_{w\downarrow} - \alpha S_{w\downarrow} + L_{w\downarrow} - \sigma T_s^4 = H + \lambda E + G + \frac{C}{\Delta t} (T_s - T_{s1})^n \]

\[ T_s^4 = T_{s1}^4 \left(1 + \frac{T_s - T_{s1}}{T_{s1}}\right)^4 \]
Impact of vegetation canopy

No canopy

Canopy

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Impact of Vegetation Canopy

No canopy

Canopy
Heterogeneity
Future developments

• Multi-stage surface energy balance calculations
  i. Fully explicit calculation
  ii. Penman Monteith calculation
  iii. Implicit atmospheric calculation

• Multiple source tiles
Questions and answers